

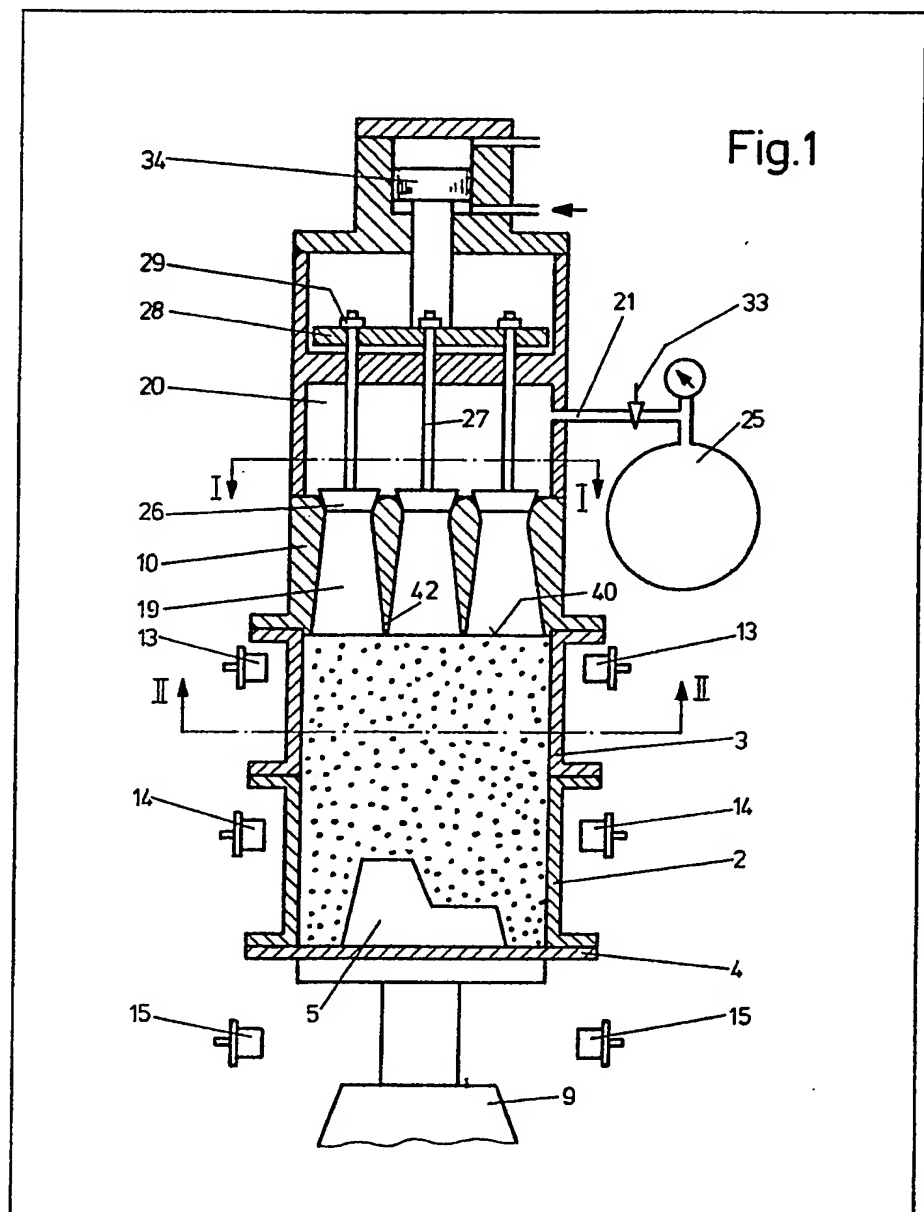
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(54) Process and apparatus for compacting molding material

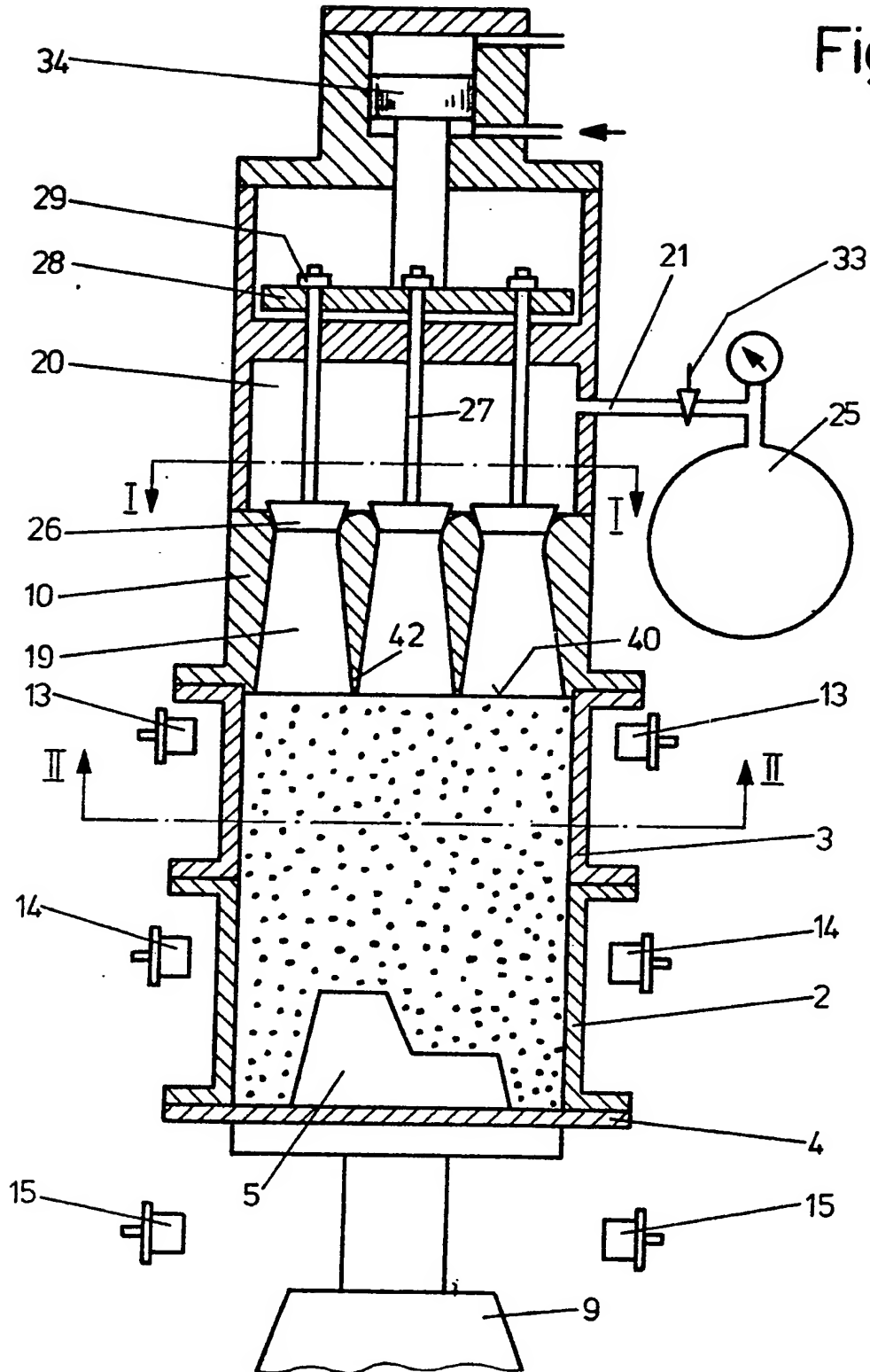
(57) In a method of compacting molding material a compressed gas is caused to pass through a plurality of supersonic nozzles (19) by abruptly opening valves (26) between a compression chamber (20) and the molding material container (2, 3). The nozzles are aligned perpendicularly to

the surface of the molding material, and the gas is accelerated to supersonic speed so that the pressure energy of the gas is converted optimally into kinetic energy, permitting the gas to strike the surface of the moulding material (sand) at great speed, resulting in sudden compaction. The apparatus includes nozzle and valving mechanism for accomplishing the method.



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Fig.1



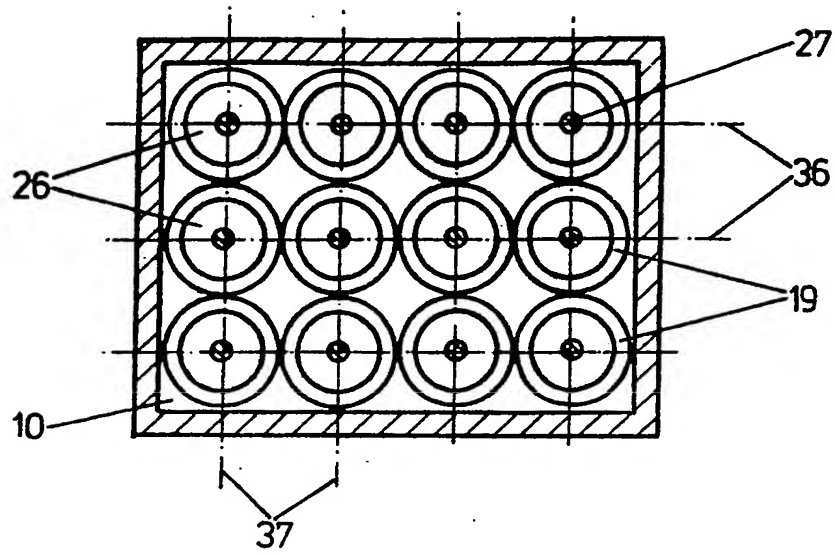


Fig. 2

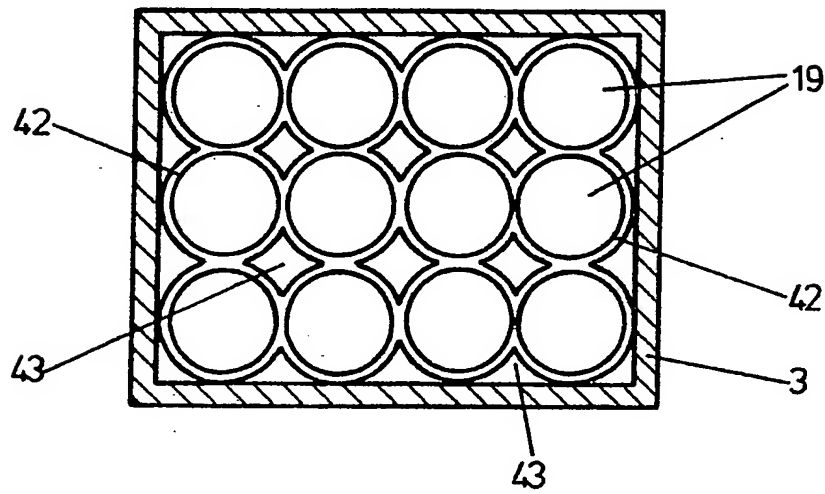


Fig. 3

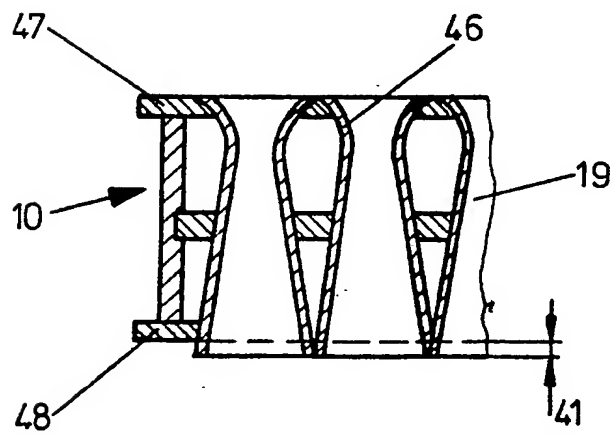


Fig. 4

## SPECIFICATION

## Process and apparatus for compacting molding material

5 This invention relates to a process for compacting loosely poured molding material, and to an apparatus for accomplishing this method.

10 Devices are known in the prior art for using pulses of compressible gas for compacting molding material. For example, German Patent 1,097,622 shows an arrangement for compressing or compacting foundry molding sand by compressed air. In a bottom plate of a compressed air bell, there are apertures which are provided with valves which can be opened abruptly by means of a lever so that a surge of air under pressure can act upon sand in a filling frame located beneath the air bell, whereupon the surge of air compacts the sand. However, in this apparatus, there are disadvantageous losses of pressure resulting from the passage of the air through the bottom plate and, additionally, losses of flow velocity occur because of the resulting turbulence. In addition, the pressure wave continues in the direction against the lateral walls of the filling frame, resulting in an additional loss of energy.

15 Accordingly, it is an object of the present invention to avoid the foregoing disadvantages and to provide a method and apparatus by which the losses of energy are reduced to a minimum and an effective pressure action which precisely impinges upon the desired surface is made possible.

20 A further object is to provide a process for compacting molding material by accelerating the compressed gas during its expansion to supersonic speed in a direction perpendicular to the exposed, flat surface of the molding material.

25 A further object is to provide an apparatus wherein the compressed gas is caused to pass through one or more supersonic converging-diverging nozzles having central axes aligned perpendicular to the surface of the molding material.

30 The type of nozzle employed is known as a Laval nozzle which is a supersonic converging-diverging flow nozzle wherein the pressure energy of the gas is converted into kinetic energy, such that the gas emerges at great speed therefrom. The rapidly moving gas strikes the surface of the sand and the energy is transferred quickly at that surface. As a result of the pressure of the striking gas, the sand is suddenly displaced and is compacted.

35 The conversion of the energy takes place in the Laval nozzle with very small losses. It is known to provide Laval nozzles with degrees of efficiency up to 98%.

40 Because the pressure wave of the gas is directed perpendicularly onto the surface of the molding sand, the kinetic energy of the gas is absorbed substantially entirely by the sand and not by the walls of the molding box into which the sand has been placed.

45 As a result of the expansion without any significant losses due to friction and flow, the initial pressure in the pressure gas chamber can be lower than in previously known devices, reducing the cost of the apparatus. Moreover, the pressure gas chamber can be designed for a lower pressure.

50 Briefly described, the invention includes a process for compacting molding material by the action of a gas under excess pressure comprising the steps of providing a container of loosely poured molding material having an exposed surface, and accelerating the gas under excess pressure during its expansion through a supersonic nozzle to supersonic speed in a direction toward and perpendicular to the exposed surface.

55 In another aspect, the invention includes, in an apparatus for compacting a mass of loosely poured molding material wherein the apparatus includes a compressed gas source, a compressed gas chamber coupled to the source and having an exit plate with means defining at least one closable gas passage aperture, a filling frame, and a mold box for receiving the molding material and a pattern, the filling frame and mold box being connectable to the exit plate, the improvement wherein the means defining the at least closable gas passage aperture comprises a supersonic converging-diverging nozzle the central flow axis of which is aligned perpendicular to the exposed surface of the molding material.

60 In order that the manner in which the foregoing and other objects are attained in accordance with the invention can be understood in detail, particularly advantageous embodiments thereof will be described with reference to the accompanying drawings, which form a part of this specification, and wherein:

65 Fig. 1 is a schematic side elevation, in section, of an apparatus in accordance with the invention; Fig. 2 is a transverse sectional view along line I—I of Fig. 1;

70 Fig. 3 is a transverse sectional view along line II—II of Fig. 1; and

75 Fig. 4 is a partial side elevation, in partial section, of a further embodiment of a portion of an apparatus usable in the structure of Fig. 1.

80 Fig. 1 shows a molding box 2 above which is a filling frame 3 and below which is a master plate 4 carrying a mold 5, plate 4 being supported on a thrust piston driven by a piston drive 9 so that the plate 4, molding box 2 and filling frame 3 can be moved upwardly to the position shown in Fig. 1 such that the upper edge of the filling box is in contact with the lower portion of a bottom or exit plate 10. The filling frame, molding box and master plate can be sequentially lowered and separated in sequence so that they are, respectively, supported on pairs of rollers schematically illustrated at 13, 14 and 15. The bottom or exit plate 10, which is formed in one piece, is provided with a plurality of gas passage apertures 19 which are in the form of supersonic converging-diverging flow nozzles known as Laval nozzles, the exit plate constituting the bottom

portion of a compressed air chamber 20. The compressed air chamber 20 is connected to a source of compressed air 25 through a closable feed line 21 provided with a valve 33. Passages 19 can be closed by means of valves 26 which are connected to valve tappets 27 are operable by movement of a valve operating plate 28.

Preferably, the valve tappets 27 are individually adjustable as to height by means of nuts 29 which adjustment can be accomplished to ensure simultaneous operation of all valve tappets 27.

When valves 26 are closed, compressed air from source 25 is allowed to enter chamber 20 until chamber 20 reaches pressure equilibrium with source 25, after which valve 33 in line 21 is closed. Then, the valve operating plate 28 is abruptly raised by supplying fluid pressure to a piston and cylinder assembly including a piston 34 which is coupled to the valve plate, causing the piston to suddenly rise, abruptly opening all of valves 26 from the upper ends of passages 19. The air under pressure in chamber 20 then expands or relaxes through the Laval nozzles which are aligned perpendicularly with respect to the upper exposed surface of the loosely poured molding sand in the filling frame 3, and the gas is thus accelerated. At the same time, an over critical discharge of the gases occurs wherein the pressure decreases in the enlarged cross-section in the through-flow direction toward the throat with the narrowest cross-section of the Laval nozzle, which causes a further acceleration of the gas beyond the speed of sound prevailing in the narrowest cross-section.

Although satisfactory results can be achieved with only one passage aperture 19, it is more advantageous to construct the exit plate 10 so that apertures 19 exist across substantially the entire surface of the plate, the apertures lying as closely adjacent each other as possible, somewhat as shown in Fig. 2. In that way, an even effect of the flow of gas over the entire surface of the molding material can be achieved. The apertures 19 are aligned in accordance with a raster system illustrated in Fig. 2, the raster consisting of intersecting lines 36, 37 which are perpendicular to each other, this arrangement permitting advantageous utilization of the entire surface of exit plate 10.

In the embodiment described, the compressed gas is compressed air. However, steam or other gases can alternatively be used. It has been found that using relatively low pressures of about 8 bar in the chamber 20, molds can be produced which have compression strengths of about 20 N/cm<sup>2</sup>.

The molding material is advantageously filled up to the upper edge of filling frame 3 in such a way that a level upper surface of the molding material can be formed simply by wiping. By thus forming a level exposed surface of the molding material, problems are avoided arising from individual streams of air from the Laval nozzle coming in contact with one another and giving rise to a situation in which the streams can mutually impede each other.

For a better separation of the air streams, the exit plate 10 is provided with projections 40 which extend over substantially the entire cross section of the filling frame 3 and which have a height illustrated in Fig. 4 at 41. These projections 40 project into the filling frame and, thus, into the molding material. However, in order to avoid mechanical compression of the molding material in these regions by the projections, the projections are formed with sharp lower edges 42. This will be achieved through the fact that the parts 43 between the individual edges 42 and also between the edges 42 and the filling frame 3 are redispersed by the level 41 of the projection 40.

A further advantageous embodiment of the exit plate 10 is shown in Fig. 4. In that embodiment, the exit plate is formed as a frame-like housing into which Laval nozzle inserts 46 are positioned. The housing has an upper closing plate 47, the exposed surface of which is substantially flush with the entry ends of the nozzles 46, and a lower plate 48 faces the filling frame 3 with the discharge ends of the nozzles 46 projecting beyond the plate 48 by distance 41, forming projections 40, so that, in this embodiment also, an effective separation of the partial streams is assured.

The nozzle apertures can be developed conically so that they are circular in cross section. However, polygonal cross sections such as square, or a mixture of cross sections, are also possible. As will be recognized, the invention can be employed for the compression of any kind of molding substance which is loose and requires compaction.

While certain advantageous embodiments have been chosen to illustrate the invention it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

#### CLAIMS

1. A process for compacting molding material by the action of a gas under excess pressure comprising the steps of providing a container of loosely poured molding material having an exposed surface, and accelerating the gas under excess pressure during its expansion through a supersonic nozzle to supersonic speed in a direction toward and perpendicular to the exposed surface.

2. A process according to claim 1 and including leveling the exposed surface of the material before compaction, and slightly immersing the discharge end of the supersonic nozzle in the material before accelerating the gas therethrough.

3. In an apparatus for compacting a mass of loosely poured molding material wherein the apparatus includes a compressed gas source, a compressed gas chamber coupled to the source and having an exit plate with means defining at least one closable gas passage aperture, a filling frame, and a mold box for receiving the molding

material, and a pattern, the filling frame and mold box being connectable to the exit plate, the improvement wherein

5 said means defining the at least one closable gas passage aperture comprises a supersonic converging-diverging nozzle the central flow axis of which is aligned perpendicular to the exposed surface of the molding material.

10 4. An apparatus according to claim 3 wherein said exit plate is provided with a plurality of closely spaced gas passage apertures occupying substantially the entire surface of said plate.

15 5. An apparatus according to claim 4 wherein said apertures are centered on a raster system pattern formed by intersecting perpendicular lines.

6. An apparatus according to any of claims 3, 4 or 5 wherein said exit plate is formed in one piece.

20 7. An apparatus according to any of claims 3, 4 or 5 wherein said exit plate includes projections protruding into said filling frame, said projections being distributed over the area of said plate.

8. An apparatus according to claim 7 wherein the spaces between the apertures are reduced to a minimum by the extent of said projections.

25 9. An apparatus according to any of claims 3, 4

or 5 wherein said exit plate comprises a housing having said nozzles mounted therein.

30 10. An apparatus according to claim 9 wherein said housing includes a bottom cover plate and wherein the exit ends of said nozzles protrude beyond said housing by a predetermined distance.

11. An apparatus according to any of claims 3, 4 or 5 wherein the cross section of each said aperture is circular.

35 12. An apparatus according to either of claims 4 or 5 and further comprising a plurality of valve members closing said apertures, and

40 a valve operating plate coupled to all of said valve members such that operation of said valve plate causes simultaneous opening of all of said valve members.

45 13. A process according to claim 1 and substantially as hereinbefore described with reference to, and as shown in the accompanying drawings.

50 14. Apparatus according to claim 3 and substantially as hereinbefore described with reference to, and as shown in the accompanying drawings.